2.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

This section lays the foundation for developing a range of remedial action alternatives to address the risks at the Portland Harbor Site. The information presented in this section identifies applicable, relevant, and appropriate requirements (ARARs); develops remedial action objectives (RAOs) that consider the contaminants and media of interest, exposure pathways and preliminary remediation goals; identifies general response actions (GRAs) focused on contaminated sediments and riverbanks; and screens remedial technologies and process options related to each GRA based on consideration of site-specific information.

The information presented in this section was developed consistent with EPA *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (USEPA 1988), EPA *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (USEPA 2005), and EPA *Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites* (USEPA 2002).

2.1 APPLICABLE, RELEVANT, AND APPROPRIATE REQUIREMENTS

Section 121(d) of CERCLA requires remedial actions to generally comply with all applicable or relevant and appropriate federal environmental or promulgated state environmental or facility siting laws, unless such standards are waived. CERCLA provides that a remedy that does not attain an ARAR can be selected if the remedy assures protection of human health and the environment and meets one of six waiver criteria described in Section 2.1.3.2.

“Applicable requirements” are defined in 40 CFR 300.5 as:

> *“those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable.”*

while “Relevant and appropriate requirements,” are defined as:

> *“those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws, that, while not ‘applicable’ to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate."*

In addition to ARARs, advisories, criteria, or guidance may be identified as To Be Considered (TBC) for a particular release. As defined in 40 CFR 300.400(g)(3), the TBC category "consists of advisories, criteria, or guidance developed by the U.S. EPA, other federal agencies, or states that may be useful in developing CERCLA remedies." TBCs may be non-promulgated advisories or guidance that are not legally binding and do not have the status of potential ARARs.

Under CERCLA 121(e), federal, state, or local permits need not be obtained for remedial actions which are conducted entirely on-site. "On-site" is defined as the "areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the response action" (40 CFR 300.5). Although a permit would not have to be obtained, the substantive (non-administrative) requirements of the permit must be met. Remedial activities performed off-site would require applicable permits.

2.1.1 Portland Harbor ARARs

Three categories of ARARs were identified for use in the FS:

- Chemical-specific requirements (**Table 2.1-1**)
- Location-specific requirements (**Table 2.1-2**)
- Performance, design, or other action-specific requirements (**Table 2.1-3**)

This sections discusses the most significant ARARs and their general requirement and criteria. Other ARARs may be discussed throughout the FS as relevant to the evaluation being presented. The list of potential ARARs and TBCs will be refined throughout the FS process with ARARs finalized in the decision document.

Chemical-Specific ARARs
Chemical-specific ARARs are usually health- or risk-based values or methodologies that, when applied to site-specific conditions, result in the establishment of numerical values that can be used as remediation goals or cleanup levels. If more than one such ARAR is available for a specific contaminant, alternatives should generally comply with the most stringent. Sediment, surface water, and groundwater have been identified as media of concern at the Site. Although there are no promulgated federal or Oregon ARARs providing numerical standards for contaminants in sediment, both federal and Oregon standards and criteria are available for surface water and groundwater. Oregon has promulgated acceptable risk levels for human and ecological receptors as described below.

In addition to Oregon WQS, CERCLA requires a remedy attain the federal National Recommended Water Quality Criteria (NRWQC) developed that are protective of ecological receptors and human consumers of fish and shellfish, if relevant and appropriate to the circumstances of the release of hazardous substances at the site [42

USC 9621(d)(2)(A)]. Specific Oregon WQS and federal NRWQC and other chemical-specific ARAR numeric values are provided in **Table 2.1-4**. In addition to numeric water quality criteria, Oregon narrative water quality criteria are potential ARARs that EPA will translate into numeric standards for each COC through the final remediation goals.

MCLs and non-zero MCLGs established under authority of the Safe Drinking Water Act (SDWA) are considered relevant and appropriate to groundwater and surface water at the Portland Harbor Site. Public drinking water systems in Oregon are subject to the Oregon Drinking Water Quality Act (ORS 448 – Water Systems). While the State of Oregon has exercised primary responsibility for administering the federal SDWA, in practice, the Oregon drinking water standards match the national standards.

Oregon Hazardous Substance Remedial Action Rules set standards for the degree of cleanup required and establish acceptable residual risk levels for humans. It requires that hazardous substance remedial actions achieve one of three standards: "a) acceptable risk levels as defined in OAR 340-122-0115 as demonstrated by a residual risk assessment, b) numeric cleanup standards developed as part of an approved generic remedy…, or c) for areas where hazardous substances occur naturally, the background level of the hazardous substances if higher than those levels specified in subsections [(a) and (b), above]." Subsection (b) is not an ARAR for this site because this cleanup is not a generic remedy as defined in Oregon's rules. Therefore, OAR 340-122-0040(2)(a) and (c), and the relevant risk levels defined in OAR 340-122-0115 are ARARs. The following acceptable risk levels under OAR under part (a) above are considered applicable to the Portland Harbor site:

- A 1 in 1,000,000 (1×10^{-6}) lifetime excess cancer risk for individual carcinogens
- A 1 in 100,000 (1×10^{-5}) cumulative lifetime excess cancer risk for multiple carcinogens
- A hazard index[1] (HI) of 1 for non-carcinogens

Location-Specific ARARs

Location-specific ARARs are restrictions placed on the concentration of hazardous substances or the conduct of activities in specific locations. Examples include floodplains, wetlands, archaeological or cultural resources, historic places, the presence of threatened or endangered species and sensitive ecosystems or habitats. Federal Emergency Management Act (FEMA) regulations at 44 CFR 9 set forth the policy, procedure and responsibilities of federal agencies to implement and enforce Executive Orders 11988 (Management of Floodplain), as amended by E.O. 13690, and E. O. 11990 (Wetlands Protection) and the FEMA regulations. Although policy, including executive orders, are not ARARs, the FEMA regulations that require projects not adversely impact existing flood storage capacity without appropriate mitigation are

[1] An HI represents the sum of individual contaminant HQs

ARAR. Likewise, the FEMA regulation ARAR requires that any action (such as sediment cleanup) that encroaches on the floodways of United States waters cannot cause an increase in the water surface elevation of the river during a 100-year flood event.

Section 7 of the Endangered Species Act (ESA), 16 USC 1536(a)(2), requires that actions authorized by federal agencies may not jeopardize the continued existence of endangered or threatened species or destroy or adversely modify critical habitat. It is EPA policy to consult with the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) to ensure that actions are not likely to jeopardize the continued existence of any threatened or endangered species or result in adverse modification of species' critical habitat. If a jeopardy, or adverse modification opinion is issued by NMFS or USFWS, the opinion will include "reasonable and prudent alternatives" that are designed to allow the project to proceed in a manner that will not jeopardize the continued existence of the listed species, or adversely modify designated critical habitat. Five species of listed salmonids are known to use the lower Willamette River as a rearing and migration corridor. Moreover, eight listed salmonid species, three additional listed fish species, and one listed mammal species are known to occur in the lower Columbia River near the confluence with the Willamette River. A preliminary biological assessment will be developed for the proposed remedy to ensure that the proposed cleanup action is not likely to jeopardize the continued existence of any threatened or endangered species present at the site. Further consultation with NMFS and USFWS will be required prior to implementation of cleanup activities at the Portland Harbor Site.

Action-Specific ARARs

Action-specific ARARs are usually technology- or activity-based requirements or limitations on actions taken with respect to hazardous wastes. These requirements are triggered by the particular remedial activities that are selected to accomplish a remedy. These action-specific requirements do not in themselves determine the remedial alternative; they instead indicate how a selected alternative must be conducted. Some federal and state requirements may be both location-specific and action-specific ARARs because they are invoked due to an action occurring on critical habitat or other special location, and they place limits or requirements on how such action is conducted.

Section 404 of the Clean Water Act (CWA) regulates the discharge of dredged or fill material into navigable waters, with the exception of incidental fallback associated with dredged materials. This ARAR is applicable to cleanup actions in navigable waters of the Site that will discharge dredged material or capping material into the Willamette River or adjacent wetlands, including the specification of in-water disposal sites. The alternative evaluation process includes considerations of the CWA hierarchy to avoid or minimize loss of aquatic habitat or function, but if a loss was deemed unavoidable, then mitigation will included as part of the alternative. The final assessment of loss and determination of mitigation will be made during remedial design.

Section 10 of the Rivers and Harbors Act prohibits the unauthorized obstruction or alteration of any navigable water, meaning cleanup activities need to be conducted in a way that does not obstruct navigation.

2.1.2 ARAR Waivers

The NCP provides for waivers of ARARs under certain circumstances. According to 40 CFR 300.430(f)(1)(ii)(C):

"An alternative that does not meet an ARAR under federal environmental or state environmental or facility siting laws may be selected under the following circumstances:

1. *The alternative is an interim measure and will become part of a total remedial action that will attain the applicable or relevant and appropriate federal or state requirement;*

2. *Compliance with the requirement will result in greater risk to human health and the environment than other alternatives;*

3. *Compliance with the requirement is technically impracticable from an engineering perspective;*

4. *The alternative will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirement, or limitation through use of another method or approach;*

5. *With respect to a state requirement, the state has not consistently applied, or demonstrated the intention to consistently apply, the promulgated requirement in similar circumstances at other remedial actions within the state; or*

6. *For Fund-financed response actions only, an alternative that attains the ARAR will not provide a balance between the need for protection of human health and the environment at the site and the availability of Fund money to respond to other sites may present a threat to human health and the environment."*

The basis for ARAR waivers, including technical impracticability, is presented in USEPA 1989a.

2.2 REMEDIAL ACTION OBJECTIVES

RAOs consist of media-specific goals for protecting human health and the environment. RAOs provide a general description of what the cleanup is expected to accomplish and help focus alternative development and evaluation.

RAOs specify:

- Contaminants of concern (COCs) for each media of interest;
- Exposure pathways, including exposure routes and receptors; and
- An acceptable contaminant concentration or range of concentrations for each exposure route.

The following general narrative RAOs have been developed for the Portland Harbor site:

Human Health

- **RAO 1** – **Sediments:** Reduce cancer and noncancer risks to people from incidental ingestion of and dermal contact with COCs in sediments and beaches to exposure levels that are acceptable for fishing, occupational, recreational, and ceremonial uses.
- **RAO 2** – **Biota**: Reduce cancer and noncancer risks to acceptable exposure levels (direct and indirect) for human consumption of COCs in fish and shellfish.
- **RAO 3 – Surface Water:** Reduce cancer and noncancer risks to people from direct contact (ingestion, inhalation, and dermal contact) with COCs in surface water to exposure levels that are acceptable for fishing, occupational, recreational, and potential drinking water supply.
- **RAO 4** – **Groundwater:** Reduce migration of COCs in groundwater to sediment and surface water such that levels are acceptable in sediment and surface water for human exposure.

Ecological

- **RAO 5** – **Sediments:** Reduce risk to ecological receptors from ingestion of and direct contact with COCs in sediment to acceptable exposure levels.
- **RAO 6 – Biota (Predators):** Reduce risks to ecological receptors that consume COCs in prey to acceptable exposure levels.
- **RAO 7** – **Surface Water:** Reduce risks to ecological receptors from ingestion of and direct contact COCs in surface water to acceptable exposure levels.
- **RAO 8** – **Groundwater:** Reduce migration of COCs in groundwater to sediment and surface water such that levels are acceptable in sediment and surface water for ecological exposure.

RAO 9 – River Banks: Reduce migration of COCs in river banks to sediment and surface water such that levels are acceptable in sediment and surface water for human health and ecological exposures.

Achieving the above RAOs relies on remedial alternatives' ability to meet cleanup levels derived from PRGs. At this point **Table 2.2-1** provides PRGs which are based on such factors as risk, ARARs, and background. PRGs may be further modified through the evaluation of alternatives and the remedy selection process. Final cleanup levels will be selected in the Record of Decision.

It is EPA's expectations that the State's actions to address source control will adequately address groundwater contamination. Should groundwater not be addressed adequately under those actions, EPA may at a future time determine if action is warranted under CERCLA to address groundwater. The RAOs above relate to the action being conducted under CERCLA, and meeting the above objectives is dependent on the source control actions being conducted by ODEQ. In addition, an objective for addressing groundwater contamination is not included in this action as groundwater contamination is primarily due to the upland sources being addressed by the ODEQ source control actions.

The following subsections discuss the development of PRGs for each RAO. The PRG identification process consists of the following steps:

1. Identification of the COCs (Section 2.2.1).
2. Development of PRGs for the applicable exposure routes and receptors (Section 2.2.2).
3. Identification and selection of potential target areas and volume estimate for remediation (Section 2.2.3)

2.2.1 Contaminants of Concern

EPA guidance defines COCs as a subset of the contaminants of potential concern[2] (COPCs) that are identified in the RI/FS as needing to be addressed by the response action proposed in the ROD (USEPA 1999). Identification of COCs at Portland Harbor is based on whether the contaminant is a listed hazardous substance, the risk estimate, ecological significance of risks to ecological receptors, and chemical-specific ARARs or other statutory criteria specified in 40 CFR 300.430(e)(2)(i).

The baseline human health risk assessment (BHHRA, Kennedy/Jenks 2013) and baseline ecological risk assessment (BERA, Windward 2013) evaluated contaminants in sediments, surface water, biota, and groundwater in the Willamette River, and identified the pathways through which humans and ecological receptors could be exposed to those

[2] COPCs are defined as those contaminants potentially site-related and whose data are of sufficient quality for use in the quantitative risk assessment (USEPA 1989b).

contaminants. Based on the risk assessment, a contaminant was identified as a COC if its exposure resulted in a lifetime cancer risk greater than 1 x 10^{-6} or a non-cancer hazard quotients (HQs) greater than 1.0, provided that cumulative life time cancer risk or target HI for the receptor exceeded the upper-bound limit of the CERCLA risk range. Thus, the initial COC selection was based on an exceedance of cumulative life time cancer risk of 1 x 10^{-6} and an HI of 1.0.

The COCs for Portland Harbor are presented in **Tables 2.2-2** and **2.2-3.** Antimony was eliminated as a COC for both ecological and human health because the unacceptable risk estimates were based on a single result in smallmouth bass. These results were considered to be unrepresentative of true tissue concentrations as they are likely the result of a sinker in the gut being incorporated into the chemical analysis. Likewise, lead was eliminated as a COC for human health and ecological dietary risks that were based on the same single smallmouth bass result. **Table 2.2-2** presents the rational for selection of COCs for the FS, and **Table 2.2-3** presents the COCs related to each RAO and media and identifies whether they are risk- or ARAR-based.

Risk-Based COCs
Risk-based COCs were identified as posing unacceptable risk to human health or the environment in a specific media based on the results of the baseline risk assessments. Risk-based human health COCs were identified in beach and in-water sediment (RAO 1), fish tissue (RAO 2), and surface water (RAO 3). Risk-based ecological COCs were identified in sediment (RAO 5 and RAO 6), surface water (RAO 6 and RAO 7), pore water[3] (RAO 8), and riverbank soil (RAO 9). Risk-based COCs are denoted with an “R” in **Table 2.2-3**.

ARAR-Based COCs
Limited surface water and pore water sampling was conducted at Portland Harbor, and was not always conducted where there was a known surface water or groundwater contaminant source. Consequently, contaminants that were detected in upland media (storm water and groundwater) at concentrations that indicate the potential to migrate to the river at concentrations that exceed the Safe Drinking Water Act Maximum Contaminant Levels (MCLs) and National or State of Oregon water quality criteria were also designated as ARAR-based COCs. These are denoted with an “A” in **Table 2.2-3**. EPA expects that contaminated groundwater will be addressed through upland source control measures implemented under ODEQ regulatory authority. However, since groundwater plumes may extend beyond the point of upland control and into the river, EPA considers these as COCs for those areas and in determining protective measures for the river environment.

[3] For the purposes of this FS, pore water is defined as interstitial water of bulk sediment within the biologically active zone.

2.2.2 Development of Preliminary Remediation Goals

The preliminary remediation goals are developed on the basis of site-specific and default risk-related factors, chemical-specific ARARs, when available, and consideration of background concentrations. Risk-based PRGs were developed to address unacceptable human health and ecological risks identified in the BHHRA and BERA, consistent with the NCP [300.430(e)(2)(i)]. These PRGs represent concentrations in environmental media which are protective of both human and ecological receptors for each RAO.

2.2.2.1 Human Health Risk-Based PRGs

The BHHRA evaluated exposures and associated risks and hazards based on a number of current and potential land uses. Specific receptors evaluated were dockside workers, in-water workers, transients, recreational beach users, tribal, recreational, and subsistence fishers, divers, people using surface water for domestic household purposes; and infants consuming breast milk from mothers exposed to certain bioaccumulative contaminants via one or more of the completed exposure pathways. Risk-based PRGs were calculated using the reasonable maximum exposure assumptions from the BHHRA, consistent with the NCP. They were developed for COCs in sediment and biota tissue, assuming target cancer risk levels of 10^{-6} (point of departure) and 10^{-4} (for informational purposes), and a target non-cancer hazard of 1, for each of the receptors evaluated in the BHHRA and using the methodology described in **Appendix B1**.

Risk-based PRGs were calculated based on direct contact with beach and in-water sediment (RAO 1), as well as to be protective of direct and indirect exposures through consumption of fish and shellfish (RAO 2). Risk-based sediment PRGs protective of fish/shellfish consumption were not developed for arsenic, mercury, BEHP, and PBDEs because a relationship between fish and shellfish tissue and sediment concentrations could not be determined. The risk-based PRGs for RAOs 1 and 2 represent the lowest value in each media (beach or in-water sediment, and fish/shellfish tissue) to be protective of all potential receptors. These risk-based values are presented in **Tables 2.2-4** and **2.2-5**.

MCLs and EPA regional screening levels (RSLs) for tap water (EPA 2014) were used to set PRGs for RAOs 3 and 4. These values are presented in **Tables 2.2-6 and 2.2-7**. RSLs are only used when MCLs or ARARs are not available for a specific contaminant.

2.2.2.2 Ecological Risk-Based PRGs

Ecological risk-based PRGs were developed for sediment, surface water, and pore water to meet the objectives associated with RAOs 5 through 8. The ecological risk-based PRGs were developed from medium- and contaminant-specific toxicity reference values (TRVs) protective of ecological receptors and used in the BERA, the process is detailed in **Appendix B2**.

Risk-based PRGs in sediment were selected from TRV values presented in the BERA that are protective of ingestion and direct contact with sediments (RAO 5) and calculated for upper trophic level receptors based on consumption of prey (RAO 6). The lowest value for each media was selected as the risk-based PRG for RAOs 5 and 6 to be protective of all potential receptors. Since water contributes to the exposure to PCBs and dioxins/furans for RAO 6, water TRVs in Attachment 10, Table 2 of the BERA were used for RAO 6. Water TRV values from Attachment 10, Table 2 in the BERA that are protective of ecological receptors were selected as risk-based PRGs for RAOs 7 and 8. The risk-based PRGs selected for RAOs 5 through 8 are presented in **Tables 2.2-8** through **2.2-11**.

2.2.2.3 PRGs Based on Chemical Specific ARARs

Chemical specific ARARs were discussed in Section 2.1.1. The PRGs for RAOs 3 and 4 were based on the State of Oregon AWQCs (organism + water) and MCLs presented in **Table 2.1-4**. The lower of the values identified for a particular contaminant was chosen as the ARAR-based PRG. These values are presented in **Tables 2.2-6 and 2.2-7**. The PRGs for RAO 7 was based on the State of Oregon AWQC (chronic aquatic life) presented in **Table 2.1-4**. These values are presented in in **Table 2.2-10**.

2.2.2.4 PRGs Based on Background Concentrations

Background concentrations may be used to develop remedial goals when risk-based PRG concentrations are less than naturally-occurring or anthropogenic background (USEPA 2002). In this context, the sediment background concentrations reflect substances or locations that are not influenced by the releases from the site and are either naturally occurring or anthropogenic. The derivation of background concentrations in sediment for the Portland Harbor Site is described in Section 7 of the RI Report. There are insufficient data to compute defensible background concentrations for other media. Background sediment concentrations are presented in **Tables 2.2-4, 2.2-5, 2.2-8 and 2.2-9**.

2.2.2.5 Selection of Preliminary Remediation Goals

PRGs for Portland Harbor are developed from site-specific risk-based PRGs, chemical-specific ARARs (when available), and consideration of background concentrations. The risk-based PRGs are compared to the chemical-specific ARARs, and the lower of the two values was then compared to background. Where both the risk-based PRGs and chemical-specific ARAR are less than the background concentration, the background concentration is selected as the final PRG. This process and the selected PRGs for each RAO are presented in **Tables 2.2-4** through **2.2-11**. PRGs for RAO 9 were selected as the lowest sediment PRG for each COC; the process and selected PRGs are presented in **Table 2.2-12**. **Table 2.2-1** provides a summary of the selected PRGs for all RAOs and the basis for each PRG is presented in **Table 2.2-3**.

2.2.3 Identification and Selection of Potential Sediment Target Areas for Remediation

When developing remedial alternatives, it is necessary to identify the sediments that should be evaluated for remediation to meet the RAOs. Criteria for making this identification typically include identifying areas exceeding PRGs, as well as geochemical and statistical interpretations of contaminant concentration data and sediment characteristics. These analyses are described in detail in Section 3 of the RI Report and are summarized below.

The river's cross-sectional area increases steadily from RM 12 to RM 9. In this area, a change in sediment texture is also observed (**Figure 2.2-1**). The river bed upstream of RM 11.8 is predominantly coarser sediments with smaller areas of silt, often located outside the navigation channel. The Study Area (below RM 11.8) sediments are predominately fine-grained material (silts) bank-to-bank, with pockets of coarser material (sand and gravel). At RM 8, the river narrows and the sediments are predominately coarser material until about RM 5, where the river cross-sectional area increases and sediments are again predominately finer grain material. Approximately 61 percent of the surface sediments in the Study Area and about 69 percent of the volume is comprised of fine-grained materials (silts). The federally-authorized navigation channel encompasses approximately 60 percent of the riverbed within the Study Area. Due to a combination of a wider cross-section and a deeper navigation channel (40 to 43 feet) below RM 11.8, thicker and wider beds of contaminated sediments accumulated in these areas.

Commented [KK1]: This is Figure 2.1-3 from the Draft FS.

Analysis of surface sediment contamination resulted in a series of observations that form the basis for much of the CSM. Most of the contaminants examined in studies conducted between 1995 and 2010, exhibited a broad range of concentrations (spanning an order of magnitude or more) within a given river mile interval within the Study Area. Obvious areas of elevated concentrations were observed at the point of release, with decreasing concentrations moving downstream. This same trend is also evident in the median concentrations by river miles (see **Tables 5.2-3, 5.2-5** and **5.2-7** in the Final RI Report). Within the Study Area, the majority of the contamination is located in the nearshore areas. Some river miles are contaminated with only a few contaminants while others are contaminated with multiple contaminants. Certain contaminants (PCBs, metals) are found site-wide, while others (PAHs, DDx, dioxins/furans) are found in only portions of the Study Area. In many cases, concentrations in subsurface sediments are higher than those measured in surface sediments. Since much of the site is erosional or transitional (deposition in some parts of the year and erosional in others) and contaminant mass exists in the river sediments, there is the potential for the contamination to be transported downstream.

The area where contamination in sediments exceed the human health PRGs in the Study Area is approximately 2,450 acres (essentially the entire Study Area - **Figure 2.2-2**). However, the area of the sediments exceeding the ecological PRGs is 1,520 acres (64 percent of the Study Area). Concentrations of COCs within the Study Area are summarized in **Tables 2.2-15**. Based on this information, the entire river area from RM 1.9 to RM 11.8, including some river banks as identified in Section 1.2.3.5, are evaluated for actions under CERCLA authority because they contain COC concentrations that exceed the PRG for at least one contaminant or are a potential source of contamination to the river. However, the entire river area may not need physical construction activities (capping or dredging) for the remedy to achieve remedial action objectives and cleanup levels.

Commented [KK2]: Need to create summary statistic tables similar to RI Section 5.2 tables and associated Appendix D tables for COCs.

2.3 GENERAL RESPONSE ACTIONS

This section identifies the general response actions for the remedial alternatives evaluated in this FS. General Response Actions (GRAs) are major categories of media-specific cleanup activities such as source control, monitored natural recovery, enhanced monitored natural recovery, institutional controls, containment, removal, or treatment that will satisfy the RAOs.

The focus of this FS is on contaminated sediments and river banks. Remedial actions will focus on reductions in concentrations of contaminants in sediment and riverbank soils. These remedial actions, in conjunction with source control measures, are anticipated to reduce concentrations in other media, such as ground water, surface water, upland soils, and air.

2.3.1 No Action

The NCP [40 CFR §300.430(e)(6)] provides that the No Action alternative should be considered at every site. The no action alternative reflects the site conditions described in the baseline risk assessments and remedial investigation report, and serves as a baseline against which the performance of other remedial alternatives may be compared. Under the No Action alternative, contaminated river sediments would be left in place without treatment or containment. ODOH could continue to implement existing fish consumption advisories pursuant to state legal authorities, but no institutional controls or monitoring would be implemented as part of a CERCLA response action for the Study Area. According to USEPA, 1999, No Action may be appropriate: 1) when the site or operable unit poses no current or potential threat to human health or the environment; 2) when CERCLA does not provide the authority to take remedial action; or, 3) when a previous response has eliminated the need for further remedial response (often called a “No Further Action” alternative).

2.3.2 Institutional Controls (ICs)

Institutional controls generally refer to non-engineering measures intended to affect human activities in such a way as to prevent or reduce exposure to hazardous substances, often by limiting land or resource use. These controls have no ability to reduce ecological exposures. The NCP states that remedies should not rely solely on institutional control and should be implemented in in conjunction with other remedy components. At the site, ICs may limit human exposure by instituting fish consumption advisories and limiting other activities during and after implementation of the remedy. Institutional controls may also be used to protect in-situ caps from boat anchoring and keel dragging, structure and utility maintenance and repair, and future maintenance dredging.

2.3.3 Monitored Natural Recovery (MNR)

Natural recovery typically relies on ongoing, naturally occurring processes to contain, destroy, or reduce the bioavailability or toxicity of contaminants in sediment. These processes may include physical (burial and sedimentation), biological (biodegradation), and chemical (sorption and oxidation) mechanisms that act together to reduce the risk posed by the contaminants. However, not all natural processes result in risk reduction; some may increase or shift risk to other locations or receptors. MNR includes monitoring to assess whether these natural processes continue to occur and at what rate they may be reducing contaminant concentrations in surface sediment, but does not include active remedial measures. MNR should be considered as a stand-alone remedy only when it is anticipated to meet remedial action objectives within a time frame that is reasonable compared to active remedies (USEPA 2005). Factors that should be considered in determining whether the time frame for MNR is "reasonable" include the following:

- The extent and likelihood of human exposure to contaminants during the recovery period, and if addressed by institutional controls, the effectiveness of those controls;
- The value of ecological resources that may continue to be impacted during the recovery period;
- The time frame in which affected portions of the site may be needed for future uses which will be available only after MNR has achieved cleanup levels; and,
- The uncertainty associated with the time frame prediction.

MNR may also be a component of a remedy, either in conjunction with active remediation or as a long-term measure to monitor the continued reduction of contaminant concentrations.

2.3.4 Enhanced Monitored Natural Recovery (EMNR)

In areas where natural recovery is occurring, but not at a rate sufficient to reduce risks within an acceptable time frame, enhancement or acceleration of the recovery process by engineering means can be considered. Similar to MNR, EMNR includes monitoring to assess whether natural processes continue to occur and at what rate they may be reducing contaminant concentrations in surface sediment.

An example of EMNR is the addition of a thin layer of clean sediment. This approach is sometimes referred to as "thin-layer placement" or "particle broadcasting." Thin-layer placement normally accelerates natural recovery by adding a layer of clean sediment over contaminated sediment. The acceleration can occur through several processes, including dilution of contaminant concentrations in sediment and decreasing exposure of organisms to the contaminated sediment. Thin-layer placement is typically different than the isolation caps because it is not designed to provide long-term isolation of contaminants from benthic organisms and does not require that the layer be maintained.

A three to six inch layer of material is typically used in thin layer placement. The grain size and organic carbon content of the clean sediment to be used for thin-layer placement needs to be carefully considered in consultation with aquatic biologists. In most cases, natural materials (as opposed to manufactured materials) approximating common substrates found in the area should be used. Clean sediment can be placed in a uniform thin layer over the contaminated area or it can be placed in berms or windrows, allowing natural sediment transport processes to distribute the clean sediment to the desired areas.

Another option that can be considered for EMNR includes the addition of flow control structures to enhance deposition in certain areas of a site. Enhancement or inception of contaminant degradation through additives might also be considered to speed up natural recovery. However, when evaluating the feasibility of these approaches, state and federal water programs will be consulted regarding the introduction of clean sediment or additives to the water body.

2.3.5 Containment

Containment entails the physical isolation (sequestration) or immobilization of contaminated sediment by an engineered cap, thereby limiting potential exposure to, and mobility of contaminants under the cap. Capping technologies require long-term monitoring and maintenance in perpetuity to ensure that containment measures are performing successfully because contaminated sediment is left in place.

Caps are generally constructed of granular material, such as suitable fine-grained sediment, sand, or gravel, but can have more complex designs. Caps are designed to reduce potentially unacceptable risk through: 1) physical isolation of the contaminated sediment or soil to reduce exposure due to direct contact and to reduce the ability of burrowing organisms to move contaminants to the surface; 2) stabilization and erosion protection to reduce re-suspension or erosion and transport to other sites; and/or 3) chemical isolation of contaminated media to reduce exposure from contaminants transported into the water column. Caps may be designed with different layers (including "active" capping layers that provide treatment) to serve these primary functions or in some cases a single layer may serve multiple functions.

2.3.6 In-Situ Treatment

In-situ treatment of sediments refers to chemical, physical, or biological techniques for reducing contaminant concentrations, toxicity, bioavailability, or mobility while leaving the contaminated sediment in place. It may be beneficial to conduct a site-specific treatability study to determine the effectiveness of the treatment technology in the environment of the Study Area.

Regulatory requirements may influence the need for treatment (such as RCRA Land Disposal Restrictions) and determination that some portion of the material constitutes principal threat waste and as such, treatment should be considered.

2.3.7 Sediment/Soil Removal

Removal of sediments can be accomplished either while submerged (dredging) or after water has been diverted or drained (excavation). This response results in the removal of contaminant mass from the river bed. Both methods typically necessitate transporting the sediment to a location for treatment and/or disposal. They also frequently include treatment of water from dewatered sediment prior to discharge to an appropriate receiving water body.

Dredging for environmental purposes should be distinguished from maintenance or navigation dredging. Environmental dredging is intended to remove sediment contaminated above certain action levels while minimizing the spread of contaminants to the water column and surrounding environment during dredging [National Research Council (NRC) 1997] while navigation dredging is intended to maintain waterways for recreational, national defense, and commercial purposes.

After removal, sediment often is transported to a staging or re-handling area for dewatering (if necessary), and further processing, treatment, or final disposal. Transport links all dredging or excavation components and may involve several different modes. The first element in the transport process is to move sediment from the removal area to the disposal, staging, or re-handling area. Sediment may then be transported for pretreatment, treatment, and/or ultimate disposal (USEPA 1994).

2.3.8 Ex-Situ Treatment

Ex-situ treatment involves the application of chemical, physical or biological technologies to transform, destroy, or immobilize contaminants following removal of contaminated sediments. Depending on the contaminants, their concentrations, and the composition of the sediment, treatment of the sediment to reduce the toxicity, mobility, or volume of the contaminants before disposal may be warranted. Available disposal options and capacities may also affect the decision to treat some sediment. In general, treatment processes have the ability to reduce sediment contaminant concentrations, mobility, and/or toxicity by 1) contaminant destruction or detoxification, 2) extraction of contaminants from sediment, 3) reduction of sediment volume, or 4) sediment solidification/stabilization. Regulatory requirements may influence the need for treatment (such as RCRA Land Disposal Restrictions) and determination that some portion of the material constitutes principal threat waste and as such, treatment should be considered.

The treatment of contaminated sediment is not usually a single process, but often involves a combination of processes or a treatment train to address various contaminant problems, including pretreatment, operational treatment, and/or effluent treatment/residual handling. Pretreatment modifies the dredged or excavated material in preparation for final treatment or disposal. When pretreatment is part of a treatment train, distinguishing between the two components may be difficult and is not always necessary. Pretreatment is generally performed to condition the material to meet the chemical and physical requirements for treatment or disposal, and/or to reduce the volume and/or weight of sediment that requires transport, treatment, or restricted disposal. Pretreatment processes typically include dewatering and physical or size separation technologies.

2.3.9 Beneficial Use of Dredged Sediments

Following removal and, if necessary, ex-situ treatment, dredged material could potentially be used beneficially. Sediment that meets applicable criteria for contaminant concentrations and structural properties could serve a beneficial purpose such as structural fill, lower permeability cover soils, or capping for a brownfield or landfill without pre-treatment. In some instances, ex-situ treatment, such as ex-situ immobilization, is required prior to application of dredged sediment as fill or cover material. In addition, certain ex-situ treatment processes result in an end product that can be beneficially used (such as formation of glass following vitrification or cement aggregate following certain thermo-chemical processes). However, a review of existing literature and local knowledge did not identify any examples of treated sediments being used beneficially in the region surrounding Portland Harbor. Therefore, beneficial reuse will not be considered in this FS.

2.3.10 Disposal

Disposal refers to the placement of dredged or excavated material and process wastes into a temporary or into a permanent structure, site, or facility. The goal of disposal is generally to manage sediment and/or residual wastes to prevent contaminants associated with them from impacting human health and the environment.

Disposal of removed media can either be within an in-water disposal facility specifically engineered for the sediment remediation, (such as in a confined aquatic disposal [CAD] location or confined disposal facility [CDF]) or within an upland landfill disposal facility such as operating commercial landfills.

Contaminated sediments that have been removed from the environment are typically managed in upland sanitary landfills, or hazardous or chemical waste landfills. They can also be managed within an in-water disposal facility specifically engineered for the sediment remediation.

2.4 IDENTIFICATION AND SCREENING OF TECHNOLOGY TYPES AND PROCESS OPTIONS

This section identifies and screens remedial technology types, and process options that are potentially applicable to remediate contaminated sediment in the Study Area. The technology selection and screening processes are conducted in accordance with the RI/FS guidance (USEPA 1988), the *Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites* (USEPA 2002), and the *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (USEPA 2005). Remedial technologies that are retained for further consideration based on site-specific data will be assembled into remedial action alternatives in Section 3.

The identified technology types are initially screened for technical implementability as described in Section 2.4.1 and then expanded into lists of potentially applicable process options as discussed in Section 2.4.2, and screened further for effectiveness, implementability, and relative cost. Ancillary technologies, such as sediment dispersion control options, sediment dewatering, wastewater treatment, and sediment transportation options are discussed in Section 2.4.3. Technologies and process options that were retained after the effectiveness, implementability, and cost screening are summarized in Section 2.4.4 and representative process options are retained in Section 2.4.5.

2.4.1 Identification and Initial Screening of Remedial Technology Types and Process Options

Following EPA’s RI/FS guidance (1988), the universe of potentially applicable technology types and process options identified for this site is reduced through an evaluation of technical implementability. Technology types refers to general categories of technologies while process options refers to specific processes within each technology type. The screening of technologies is based on the current Site uses and conditions and/or reasonable likely future conditions and uses for. During this screening step, process options and entire technology types are eliminated from further consideration on the basis of technical implementability. Technology types presented in this section are grouped by the GRAs identified in Section 2.3.

The evaluation of technical implementability was based on a general understanding of the chemical and physical characteristics at the site. **Table 2.4-1** presents remedial technologies and process options potentially applicable for each GRA at the Site. Shaded technologies and process options are not retained for further consideration based on implementability at this site. Remedial technologies and process options eliminated based on technical implementability were limited to certain in-situ and ex-situ treatment technologies and certain disposal options. The technology types that are retained after this initial screening are discussed in Section 2.4.5.

2.4.2 Evaluation and Screening of Process Options

Process options presented in **Table 2.4-1** that are determined to be technologically implementable are further evaluated in greater detail in this section in order to select one process to represent each technology type for further detailed evaluation in the FS. In some cases more than one process option may be selected for a technology type when two or more processes are sufficiently different in their performance that one would not adequately represent the other. The selection of a representative process for each technology type is solely for the purpose of simplifying the subsequent development and evaluation of alternatives without limiting flexibility during remedial design. The representative process provides a basis for developing performance specifications during preliminary design. However, the specific process actually used to implement the remedial action at a site may not be selected until the remedial design phase.

Process options are evaluated using the same criteria – effectiveness, implementability, and cost – that are used to screen alternatives prior to the detailed analysis. An important distinction to make is that at this time these criteria are applied only to technologies and the general response actions they are intended to satisfy and not to the site as a whole. Furthermore, the evaluation focuses on effectiveness factors at this stage with less effort directed at the implementability and cost evaluation. The application of these criteria is discussed below:

- **Effectiveness:** Effectiveness is evaluated relative to other processes within the same technology type. This evaluation focuses on the ability to handle the estimated areas or volumes of contaminated sediment and meeting the PRGs, potential impacts to human health and the environment during the construction and implementation phase, and how proven and reliable the process is with respect to the contaminants and conditions at the site.
- **Implementability:** Implementability evaluates each technology for technical and administrative feasibility of implementing a technology process. Since technical implementability is used as an initial screen of technology types and process options to eliminate those that are clearly ineffective or unworkable at this site, this subsequent, more detailed evaluation of process options places greater emphasis on the technical aspects of implementability. Administrative feasibility refers to the ability to obtain permits for those components of an action that would occur off-Site (on-Site actions would be performed under CERCLA authorities), the availability of

treatment, storage, and disposal services (including capacity), and the availability of specific equipment and technical specialists.

- **Relative Cost:** Cost plays a limited role in the screening of process options. Both capital and operation and maintenance (O&M) costs are considered. The cost analysis is based on engineering judgment, and each process is evaluated as to whether costs are low, moderate, or high relative to the other options within the same technology type.

Table 2.4-2 presents the effectiveness, implementability, and cost screening of technologies and process options. Technologies and process options that are retained after this screening are summarized in Section 2.4.5. The initial screening of technical implementability and subsequent evaluation of remedial technologies are presented on a technology-specific basis in the following sections.

2.4.3 Ancillary Technologies

Additional technologies and process options that are ancillary to the retained process options presented in Section 2.4.4 may be components of any remedial alternative implemented in the Study Area. These ancillary systems are described here in relation to their potential applicability to some of the primary technologies that are evaluated in **Table 2.4.2**.

2.4.3.1 Sediment Dispersion Control

All dredges cause some re-suspension of sediment. The amount is generally less than 1 percent of the mass of sediment removed and re-suspension can be controlled (Palermo 2005). Water-borne transport of re-suspended contaminated sediment released during dredging can often be reduced by using physical barriers around the dredging operation area, mechanical control techniques on the dredge equipment, and implementation of best management practices.

Physical Barriers

Two of the more common approaches of physical barriers include silt curtains and sheet pile walls, although several other designs are available that have been proven effective. Silt curtains are floating barriers designed to control the dispersion of sediment in a body of water. They are made of impervious flexible materials such as polyester-reinforced thermoplastic (vinyl) and coated nylon. The effectiveness of silt curtains is primarily determined by the hydrodynamic conditions in a specific location. Under ideal conditions, turbidity levels in the water column outside the curtain can be as much as 80 to 90 percent lower than the levels inside or upstream of the curtain (Francingues and Palermo 2005). Conditions that may reduce the effectiveness of these and other types of barriers include significant currents, high winds, changing water levels and current direction (i.e., tidal fluctuation), excessive wave height, and drifting ice and debris (USEPA 2005). Silt curtains are generally more effective in relatively shallow (<10 feet), quiescent water, as water depth and turbulence due to currents and waves increase, it becomes more difficult to effectively isolate the dredging operation from the ambient water.

The use of silt curtains is not expected to be effective in the main channel of the Study Area during dredging operations due to the presence of significant currents and tidal fluctuations. Consideration has been given to the use of silt curtains at off-channel areas (coves, embayments, slips, and lagoons) where the water velocities are much lower. In areas with working ship traffic, this approach would require developing a method for quickly removing and reinstalling the silt curtain during barge unloading operations. Silt curtains are retained for further consideration in the FS.

Sheet piling consists of a series of panels and piling with interlocking connections driven into the subsurface with impact or vibratory hammers to form an impermeable barrier. While the sheets can be made from a variety of materials such as steel, vinyl, plastic, wood, recast concrete, and fiberglass, lightweight materials (plastic, fiberglass, vinyl) are typically surface mounted to the piling.

Sheet pile containment structures are more likely to provide reliable containment of re-suspended sediment than silt curtains, although at significantly higher cost and with different technological limitations. Sheeting and/or piling must be imbedded sufficiently deep into the subsurface to ensure that the sheet pile structure will withstand hydraulic forces (such as waves and currents) and the weight of material (if any) piled behind the sheeting. Sheet pile containment may increase the potential for scour around the outside of the containment area and sediment re-suspension may occur during placement and removal of the structures. The use of sheet piling may significantly change the carrying capacity of a stream or river and make it temporarily more susceptible to flooding (USEPA 2005). Sheet piling may be used in localized areas to prevent migration of highly contaminated sediment during dredging or during disposal operations. Sheet piling is retained for further consideration in the FS.

Mechanical Control Techniques

Mechanical control techniques are available for mechanical and hydraulic dredges, as well as backhoes. Because conditions vary greatly throughout the study area, these equipment modifications are not considered standard practice and will be used where environmental conditions in the study area dictate the need for them.

Conventional mechanical dredging equipment, such as dredges that use a clamshell bucket, bucket ladder, or dipper and dragline, are ineffective for environmental dredging (ITRC 2014). The closed or environmental bucket is a specially constructed dredging bucket designed to reduce or eliminate increased turbidity of suspended solids from entering a waterway. Clamshell dredge buckets can also be fitted with baffles and seals to slow the movement of contaminated water and sediment. The USACE used this type of seal, which is similar to a rubber gasket, at the Fox River and Green Bay sites to minimize leakage of PCB-contaminated water and sediment from the bucket.

Additional modifications to conventional mechanical dredging equipment based on site-specific conditions include (ITRC 2014):

- Fitting the crane with longer boom (arm) for additional reach during dredging;
- Fitting an excavator with a longer arm for better access;
- Using a fixed arm bucket instead of a cable suspended bucket to increase the accuracy and precision of cuts and to provide greater bucket penetration in stiffer materials;
- Equipping the bucket with hydraulically operated closure arms to reduce bucket leakage;
- Installing a sediment dewatering and water collection and treatment facility on the barge or at a temporary staging site; and
- Installing GPS and bucket monitoring equipment to the dredge to provide the equipment operator with precise coordinate control of the bucket during dredging operations.

Recent developments in hydraulic dredging equipment have typically included project or site-specific modifications in order to achieve the following objectives (ITRC 2014):

- Increase solids content in the dredged material and lower water content.
- Prevent debris from entering the auger or pump intake.
- Pump dredged material over greater heights or distances.
- Improve on shore dewatering of dredged material.
- Reduce potential for releasing dredged sediment into the water column.

Backhoes can be modified or equipped with covers for the bucket to improve retention of the sediment and to minimize re-suspension.

Other control technologies include:

- **Pneuma Pump**. The Pneuma pump is used primarily for removal of fine-grained sediment and offers high solids concentration (up to 90 percent) in the dredge slurry, with minimal turbidity.
- **Large capacity dredges**. Larger than normal dredges designed to carry larger loads. This allows less traffic and fewer dumps, thereby providing less disturbance at a disposal site.
- **Precision Dredging**. Dredging utilizing special tools and techniques to restrict the material dredged to that specifically identified. This may mean thin layers, either surficial or imbedded, or specific boundaries.

Best Management Practices

Best management practices or operator-control techniques are important in preventing re-suspension of contaminated sediment. Different types of dredges require different operating practices to control sediment re-suspension. For any dredging operation, sediment re-suspension should be monitored and operations halted if needed to avoid excessive re-suspension of sediment. Examples of best management practices for different types of dredges include (ITRC 2014):

- Operators of bucket dredges can: 1) slow the dredge cycle time, which reduces the velocity of the bucket hitting the river bottom; 2) eliminate multiple bites (the practice of "multiple bites" involves repetitive lowering, raising and reopening the bucket to obtain a fuller sediment load); 3) avoid stockpiling of silty dredge material on the river bottom; 4) rinse the bucket at the barge to clean off excess sediment between loads; and 5) briefly stop the bucket at the waterline to allow excess water to drain before raising the bucket from the water.
- Operators of cutter head dredges can: 1) reduce rotation speed of the cutter head; 2) reduce the cutter head swing speed so the dredge does not move through the cut faster than it can hydraulically pump the sediment; 3) increase pump rates to provide more suction; 4) operate just below the sediment surface to avoid exposed blades or too deep cutting; and 5) avoid bank undercutting by removing sediment in lifts that are less than or equal to 80 percent of cutter head diameter to reduce cave-ins and sloughing of sediment.
- Operators of hopper dredges can: 1) reduce production rates to eliminate overflow of suspended sediments from the hoppers; and 2) reduce the fill level of the hoppers to avoid accidental overflow in rough water.

The active removal (pumping) of water from sediment barges during dredging is another approach to lessen sediment re-suspension and contaminant releases. The approach eliminates overflow from the sediment barges and has been successfully incorporated as a best-management practice at large-scale removals in Puget Sound (AMEC 2013).

The purpose of the BMP is to limit release of sediment and associated contaminants back into the waterway from the sediment barge. The findings from a case study of mechanical dredging document that barge overflow can represent a significant contribution to the formation of a residual layer of sediment (Dalton Olmsted & Fuglevand Inc. 2006) and can directly impact water quality and create a risk for offsite contamination.

As described in Fuglevand and Webb (2012), when dredging with an environmental mechanical dredge using an enclosed bucket, each bucket of material placed in the barge contains a portion of sediment and a portion of water because water is not allowed to drain from the bucket. During precision remediation dredging projects, a fill factor of 50 percent, meaning the dredging bucket is only half full of sediment on average over the course of the project should be targeted due to relatively thin cuts intended to avoid removal of non-impacted sediment and to avoid over-penetration of the bucket. The volume of water placed in the barges for a remediation dredging project can therefore equal the volume of sediment dredged from the waterway. Thus, a 100,000 m^3 dredging project can result in that volume of sediment placed into barges plus another 100,000 m^3 of water. Failure to manage the water in the barge during dredging can result in the release of turbid water back into the dredged area with the potential for increased sediment re-suspension and release and additional generated residuals.

Implementation of this BMP can include activities such as pumping of the excess water from the sediment barges during dredging, thereby limiting the amount of ponded water within the barge and preventing direct overflow from the barge back to the waterway. Removed water is pumped to a water management system designed to remove excess sediment and chemicals of concern prior to discharge of the water back to the waterway as dredging return water. With proper capture and management, the turbid water placed in a barge by the enclosed dredging bucket can be processed to remove suspended sediment and chemicals of concern that would otherwise be released back into the waterway causing releases (Fuglevand and Webb 2012).

2.4.3.2 Dewatering Evaluation

After removal, dredged sediment typically requires dewatering to reduce the sediment water content. Dewatering is considered a form of ex-situ treatment because it reduces the volume and mobility of contaminants. Dewatering technologies are commonly used to reduce the amount of water in dredged sediment and to prepare the sediment for transport and treatment or disposal. In many cases, the dewatering effluent will need to be treated before it can be disposed of properly or discharged back to receiving water. Dewatering is considered in greater detail here than in the physical ex-situ treatment section because of its common application in environmental dredging projects. Several factors must be considered when selecting an appropriate dewatering treatment technology including physical characteristics of the sediment, selected dredging method, and the required moisture content of the material to allow for the next re-handling, treatment, transport, or disposal steps in the process.

Three categories of dewatering that are regularly implemented include passive dewatering, mechanical dewatering, and reagent enhanced dewatering/stabilizing methods. The following sections discuss the effectiveness and implementability of various dewatering process options applicable to the Site.

Passive Dewatering

Passive dewatering (also referred to as gravity dewatering) is facilitated through natural evaporation, consolidation, and drainage of sediment pore water to reduce the dredged sediment water content. Passive dewatering is usually applied to mechanical dredging process options when space permits. It is most often facilitated through the use of an onshore temporary holding facility such as a dewatering lagoon or temporary settling basin. In-barge settling and subsequent decanting can also be an effective passive dewatering method and can reduce the overall time needed for onshore passive dewatering operations. Passive dewatering techniques can also be applied to sediment that has been hydraulically dredged where the resulting slurry is pumped into a consolidation site and the sediment slurry is allowed to settle, clarify, and dewater by gravity after the site has reached capacity. Water generated during the dewatering process is typically discharged to receiving waters directly after some level of treatment, or may be captured and transported to an off-site treatment and discharge location. Normal passive dewatering typically requires little or no treatability testing, although characteristics of the sediment such as grain size, plasticity, settling characteristics and NAPL content are typically considered to determine specific dewatering methods, to size the dewatering area, and to estimate the time frame required for implementation.

Passive dewatering is generally effective and capable of handling variable process flow rates but can require significant amounts of space (depending on the volume of material processed and the settling characteristics of the sediment) and time for significant water content reduction. Passive dewatering is a widely implemented dewatering technology for mechanically dredged sediments. It is also amenable to hydraulic dredging with placement into a settling basin or with the use of very large geotextile tubes to confine slurry and sediment during passive dewatering. Hydraulic dredge sediment dewatering with geotextile tubes has been implemented at several sites but typically requires project-specific bench-scale evaluations during remedial design to confirm its compatibility with Site sediments and to properly select and size the geotextile tubes.

Depending on the desired moisture content of the sediment, the subsequent processing or handling steps, the volume of material to be dewatered, available space, and the ability to effectively manage the dewatering effluent, passive dewatering can be an implementable dewatering technology option. Passive dewatering has been retained as a process option for the Portland Harbor Site with in-barge passive dewatering selected as the representative process option for inclusion in the development of alternatives.

Mechanical Dewatering

Mechanical dewatering involves the use of equipment such as centrifuges, hydrocyclones, belt presses, or plate-and-frame filter presses to separate coarse materials, or squeeze, press, or otherwise draw out water from sediment pore spaces. Mechanical dewatering is typically used in combination with hydraulic dredging to reduce the water content of the dredged slurry prior to ex-situ treatment (e.g., thermal) and/or disposal of the dewatered sediment. Mechanical dewatering may also be used in combination with mechanical dredging if the dredged material is hydraulically re-slurried from the barge. Sufficient onshore space is needed to accommodate the selected dewatering equipment, but this space is usually less than required for passive dewatering. A mechanical dewatering treatment train usually includes treating the dewater prior to discharge.

The mechanical dewatering treatment train typically includes screening to remove materials such as debris, rocks, and coarse gravel. If appropriate, polymers may be added for thickening prior to dewatering. These steps result in a dewatered cake that achieves project-specific volume and weight reduction goals of the dredged sediment. The mechanical dewatering process can be scaled to handle large volumes of sediment, but requires operator attention, consistent flow rates, and consistent sediment feed quality.

Mechanical dewatering is generally an effective technology for both hydraulic and mechanical dredging and has been widely implemented for a range of sediment types and sediment end uses (such as upland disposal) and is likely the most effective method of achieving moisture content reduction over shorter time frames than passive dewatering. Bench-scale tests are often performed during remedial design to develop the specific process design, select equipment, and to select polymer additives if appropriate. Mechanical dewatering has been retained as a process option for contaminated sediments at the Portland Harbor Site and may be used where appropriate based on area specific design needs.

Reagent Dewatering

Reagent dewatering is an ex-situ treatment method in the category of stabilization/solidification methods, which are discussed along with other categories of ex-situ treatment. This technology removes water by adding a reagent to the bulk sediment that binds with the water within the sediment matrix to immobilize the leachable contaminants (typically metals) and/or enhance geotechnical properties. This process increases the mass of sediment due to the addition of the reagent mass. For situations where dewatering is the single goal, the most cost-effective, available, and effective reagent or absorptive additive is used, which depending on site conditions and economics could include quicklime, Portland cement, fly ash, diatomaceous earth, or sawdust, among others. Reagent mixtures can be optimized to provide enhanced strength or leachate retardation to meet specific project requirements.

Dewatering by the addition of reagents is effective and has similar or smaller space and operational requirements as mechanical dewatering. In some cases, reagent addition and mixing can be conducted as part of the dredged material transport and re-handling process, either on the barge or as dredged material is loaded into trucks or rail cars. In other cases it can be added and mixed after offloading to the upland staging area. Also reagent addition may be used in combination with other forms of dewatering (e.g., filter press) and ex-situ treatment. Bench-scale testing is often necessary to determine the optimum reagent mixture prior to construction. However, case study information is available from other projects on the types of reagents used for sediments of various water contents, and this information is sufficient to determine the general effectiveness and implementability of this technology for this FS. For example, the Gasco Early Action used in-barge application and mixing of Portland cement as well as diatomaceous earth at the transload facility as a final dewatering “polishing” step. This approach required no extra upland treatment space or major changes to the transport and transload steps that would have otherwise been used.

A wide range of dewatering process options are likely feasible at the Site. As a result, reagent dewatering has been retained as a process option for contaminated sediments at the Portland Harbor Site and may be used where appropriate based on area specific design needs.

2.4.3.3 Wastewater Treatment

Dewatering dredged material requires managing the wastewater generated during the dewatering process (dredged material typically has a water content ranging from 50 to 98 percent depending on the dredging method) along with contact water (such as precipitation that has been in contact with contaminated material, decontamination water, and wheel wash water) from other facility operations. The purpose of wastewater treatment is to prevent adverse impacts on the receiving water body from the dewatering discharge to the lower Willamette River.

Wastewater will be generated by dewatering steps and this water will likely either require treatment prior to discharge to the lower Willamette River or disposal at a publicly owned treatment works (POTW) facility. While the draft FS necessarily assumes a representative set of process options for the general screening and alternative development procedures, this does not imply that other process options are screened out from future consideration during remedial design. Unless specifically noted otherwise, all process options discussed in this section would be potential options during remedial design. For example, there may be opportunities for handling and discharging dewater including addition of amendments to bind or absorb water, use of upland transfer or disposal holding areas to allow water to clarify before discharge, and discharge to publicly operated existing treatment facilities.

A wastewater treatment plant may be included as part of the on-site management of dredged material. An on-site wastewater treatment plant to manage wastewater for a facility handling sediment from the Portland Harbor Site may include coagulation, clarification, multi-stage filtration, and granular activated carbon adsorption with provision for metals removal, if necessary. The primary difference in the wastewater treatment plant for a hydraulic dredging operation as compared to a mechanical dredging operation would be the volume of wastewater to be treated; hydraulic dredging results in a larger volume of sediment-water slurry to be managed. The hydraulic dredging wastewater treatment plant would require a larger footprint. An on-site wastewater treatment system is retained for further consideration.

2.4.3.4 Transportation

Transportation would be a component for any remedial alternative that involves removal of contaminated sediments from the Portland Harbor Site. The transportation method included in each remedial alternative would be based upon the compatibility of that transportation method to the other process options. The most likely transportation methods are truck, rail, and barge. These are briefly discussed below.

Truck Transport

Truck transportation includes the transport of dewatered dredged material over public roadways using dump trucks, roll-off boxes, or trailers. This form of transportation is the most flexible but can be very costly over long haul distances. Truck transport also has the greatest potential to impact local streets and traffic depending on the location of the processing facility with respect to major highways. Transportation of dredged sediments via truck is retained for further consideration.

Rail Transport

Rail transportation includes the transport of dewatered dredged material via railroad tracks using gondolas or containers. Rail transport is desirable where sediment is shipped over long distances, for example, to out-of-state treatment or disposal facilities. Because rail transport requires coordination between multiple owners and many operators are unwilling to provide detailed information prior to entering actual negotiations, it is difficult to obtain accurate cost estimates. Rail transport may require the construction of a rail spur from a sediment handling facility to a main rail line. Transportation of dredged sediments via rail is retained for further consideration.

Barge Transport

Barge transportation includes the transport of dredged solids directly to a processing (dewatering) or disposal (CAD site or CDF) facility, or the transport of dewatered dredged material to a trans-shipment or disposal facility. Barge transport would likely be used for short distances such as from the dredging location to the dredged material handling facility. In addition, barge transport may be considered for longer distances if dredged material is hauled to out-of-state treatment or disposal locations that have the ability to accept barge-loaded dredged material. Transportation of dredged sediments via barge is retained for further consideration.

2.4.4 Summary of Retained Remedial Technologies and Process Options

In addition to the No Action response, the following process options have been retained for further evaluation:

- Institutional controls, including, but not limited to, commercial fishing bans, fish and shellfish consumption advisories, waterway and land use restrictions, and dredging and structural maintenance restrictions in capping areas.

- Monitored natural recovery processes, including, but not limited to, burial, sedimentation, bio-degradation, sorption, oxidation, and dispersion.

- Enhanced monitored natural recovery, including, but not limited to, thin layer capping.

- In-situ treatment using physical immobilization, including, but not limited to, solidification/stabilization and sequestration.

- Containment via engineered caps (including stone or clay aggregate material as armor), reactive caps, and geotextiles.

- Sediment removal via excavation, mechanical and hydraulic dredging, and use of specialized and small scale dredge equipment. Disposal in an off-site landfill, RCRA disposal facility, or CDF.

- Ex-situ treatment via particle separation and solidification/stabilization.

In addition, ancillary technologies for sediment dispersion control, dewatering, wastewater treatment and transportation are retained for evaluation in the FS.

2.4.5 Selection of Representative Technologies and Process Options

To proceed further with the development of the remedial alternatives and to evaluate and develop costs in subsequent chapters for this FS, it is necessary to select representative technologies and process options.

<u>No Action</u>:

The No Action response does not include any containment, removal, disposal, or treatment of contaminated sediments, no new institutional controls, and no new monitoring.

<u>Institutional Controls</u>:

Existing ODOH fish consumption advisories would continue under any of the remedial actions. Further, enhanced outreach to educate community members about the ODOH consumption advisories and to emphasize that advisories would remain in place during and after remediation would be incorporated into the active remedial alternatives. Outreach activities would focus on communities (typically communities or groups with environmental justice concerns) known to engage in sustenance fishing, with a special emphasis on sensitive populations (children, pregnant women, nursing mothers, tribal members). These activities could also include posting multilingual signs in fishing areas, distributing illustrated, multi-lingual brochures, and holding educational community meetings and workshops.

Additional institutional controls such as waterway and land use restrictions or special conditions (e.g., to protect the integrity of engineered caps) imposed on sediment disturbance activities could also be implemented as components of alternatives comprising active remedial measures.

Monitored Natural Recovery:

MNR could be included as a component of alternatives comprising active remedial measures. It includes monitoring of the water column, sediment, and biota tissue to determine the degree to which they are recovering to PRGs. Once active remediation is completed, the influx, mixing and deposition of sediment originating from suspended sediment upriver and sediment transport from adjacent sediments will subsequently determine the extent to which the sediment surface in the Study Area is recovering.

Enhanced Monitored Natural Recovery:

The application of a thin layer of sand may be necessary in some areas of the site to reduce the time for sediment concentration reductions over what is possible by relying solely on natural processes. Thus, areas that are stable (exhibit low shear stress) and are recovering naturally are candidates for EMNR. EMNR may be applied to broad areas of the study area with lower levels of contamination, net sedimentation, and where significant erosion is not a concern.

Sediment Containment:

Several process options using a variety of materials for sediment containment are retained including engineered caps (using stone or clay aggregate material as armor), reactive caps, and geotextiles. Due to the large area being considered for remediation and the limited precedent for using geotextiles, engineered sand caps with, and without, stone armor are selected as the representative process option for alternatives involving sediment containment. Reactive caps are retained to be considered in areas where there are groundwater plumes to eliminate the potential for the groundwater plume from entering the river environment. Reactive caps are also retained where there are COCs that have higher water solubility in areas with significant ground water advection, and where thinner caps are needed in order to minimize any increase in flood potential.

Sediment Removal:

Three process options for sediment removal were retained including excavation, hydraulic dredging, and mechanical dredging. Specialized and small scale dredge equipment was also retained, but will have limited use in the remedy for this site. The costs of remedial alternatives involving sediment removal are based on mechanical dredging as the representative process option because of the following:

- The additional challenges to implementability associated with the infrastructure needs for hydraulic dredging in the Portland Harbor area.
- The availability of site-specific data regarding implementation.

Although it would be possible to extend a hydraulic transport pipeline across the Willamette River by submerging it, due to the presence of berths and shipping lanes it is preferable to locate a dewatering facility of sufficient size close to the Study Area for the hydraulic dredging option.

Sediment Treatment:

Process options retained for treatment include solidification/stabilization (in-situ and ex-situ), and in-situ sequestration. The effectiveness of solidification/stabilization treatment is highly dependent on the initial COC concentrations; therefore, it is more suitable for sediment with lower COC concentrations.

Sequestration by addition of an amendment such as activated carbon to the sediments modifies the sorption capacity of non-polar organics and certain metals such as mercury. The effectiveness of sequestration is highly dependent on the initial COC concentrations and the mixture of COCs present. Multifunctional amendment blends may be used to address complex contaminant mixtures in sediments, and subsequently may enhance overall sorption capacity. Usually activated carbon serves as the backbone (for hydrophobic partitioning) and either is impregnated with the target amendment or blended in a briquette-like composite using an appropriate and non-toxic binder (e.g., clays or other binder materials; Ghosh et al. 2011). Amendments can be engineered to facilitate placement in aquatic environments, by using an aggregate core (such as gravel) that acts as a weighting component and resists re-suspension, so that the mixture is reliably delivered to the sediment bed, where it breaks down slowly and mixes into sediment by bioturbation.

Disposal of Dredged Sediments:

The three process options for disposal include an off-site landfill, a RCRA disposal facility and a CDF. RCRA regulations exclude dredged material that is subject to the requirements of CWA Section 404, which governs the disposal of the sediment in a disposal area within the navigable waters of the United States, from the definition of hazardous waste. In addition, a CDF is more efficiently integrated with dredging (transporting and offloading dredged material to a CDF causes fewer short-term impacts to the community and would be more cost-effective than transporting and offloading to an off-site landfill. Therefore, a CDF site is selected as the representative process option for disposal of dredged sediments.

However, to provide greater flexibility in managing large quantities of dredged material, disposal in an off-site landfill has also been retained as an alternative representative process option. Many RCRA Subtitle C and D landfills are located in the United States. Non-hazardous dredged materials (as defined under RCRA) are eligible for direct landfill disposal at a RCRA Subtitle C or D facility if in compliance with the individual acceptance criteria of the receiving facility. Hazardous dredged material that contain organic underlying hazardous constituents (UHCs) exceeding the universal treatment standards (UTS), but do not contain UHCs exceeding ten times the UTS for soil or sediment are eligible for direct landfill disposal at a RCRA Subtitle C facility, if the material is in compliance with the individual acceptance criteria of the receiving facility.

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